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Grain at High Altitudes

1. General Comments on Barley

Barley, the most widely cultivated cereal crop throughout the world, 1/ probably is the only cereal crop which can be cultivated successfully at an elevation of 14,000 feet. The protein content of barley varies considerably,* but in general those varieties which have

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developed in drier regions have a higher protein content than do those from humid areas. Similarly, a variety grown under dry conditions usually will have a higher protein content than if grown in an area of greater precipitation. In the absence of data concerning the protein content of barley grown at high elevations under dry conditions, it is probably safe to assume that this barley would have a protein content of at least 15 percent.

2. Sowing of Spring Barley

The severe winter temperatures encountered at high altitudes require that barley be grown as a spring crop. Although winter varieties of barley are common under less rigorous conditions, these varieties have developed in regions of mild winter conditions 2/ and will winter-kill under conditions in which winter rye and winter wheat will survive.

In areas where the growing season is circumscribed by freezing temperatures, spring barley usually is sown in April and May. 3/ 5/ At the extreme elevation of 14,000 feet, however, it is probable that the planting season extends from mid-May to mid-June, as the crop must be harvested early in September. 4/ 5/

Dr. Gustave A. Wiebe, the Department of Agriculture's foremost barley expert, has stated that barley seeding rates usually are within the range of 50 to 75 pounds (1 to 1.6 bushels)** per acre. 6/ Barley apparently is sown at a much heavier rate in the Soviet Union.

** The standard weight for common hulled barley in the United States is 48 pounds per bushel.

The average seeding rate in the USSR is reported to be about 2.6 to 3 bushels per acre with variations from 1.3 to 4.3 bushels per acre, the higher seeding rates prevailing in the northern regions. 7/ The average

seeding rate for the Transcaucasus, where barley is grown at elevations above 10,000 feet, is reported to be 3 bushels per acre. 8/ On the basis of this limited information, a seeding rate of about 3 bushels per acre for barley in high mountain areas probably would not prove inappropriate.

3. Yield of Barley

The question of yields of barley in high mountain areas is even more elusive than that pertaining to seeding rates. In the absence of empirical data one can only speculate as to what the yields might be under the circumstances. Yield is the sum of many factors --earliness, resistance to frost, to disease or to lodging, adaptation, vigor and other factors -- many of which are unknown, even to plant breeders. Barley yields of 100 bushels per acre are not unknown in the United States, but the average yield is about 27 - 28 bushels per acre. 9/ In countries where some barley is produced at high elevations, the following average yields for the years 1945-1949 are reported: 9/

| Country | Bushels per Acre |
|---|---|
| China | 24.0 |
| Manchuria | 22.2 |
| India | 15.4 |
| Pakistan | 12.7 |
| Chile | 30.3 |
| Peru | 20.0 |
| Uruguay | 13.0 |

The relationship between these average yields and the average yields of barley grown at high altitudes in these countries is not clear. Naked barley, the variety most commonly grown at high altitudes, yields considerably less than the ordinary hulled varieties. 1/ 10/ However, only a fraction of the barley produced in these countries is grown at high altitudes. On the other hand, the average yields reported for all these countries probably is substantially below the yields which could be attained in these countries because competition from the more valuable crops, primarily wheat, crowds barley to the less productive areas. 11/ All in all, it would be difficult to anticipate a potential yield of more than 10 to 15 bushels per acre for barley in high mountainous areas.

4. The Availability and Procurement of Barley Seed

The best place to obtain seed for the production of barley in any specific locality within the high mountain areas of Central Asia is the given locality in which it is planned to grow the barley, for as explained by one barley specialist,

> "...it is not until one comes close to the mountains (of Central Asia) that the number of types (of barley) becomes large. ...Each little mountain valley differs somewhat from every other one. Fields are more isolated

than those on the plains. Mountain people are somewhat closer to their plants and are more likely to preserve variations. ...I firmly believe that each valley has solved its own varietal problem." 3/

Failing to procure seed from the specific locality, one must attempt to find a variety which developed under conditions as similar as possible to those prevailing in the location where it is intended to plant this crop -- "The barley suited for mountaintops comes from mountaintops." 3/ Barleys from the Pamirs, Mongolia and Ethiopia have grown well at an elevation of 13,000 feet in Peru; 3/ barleys from Mount Everest, the Pamirs, and the Ethiopian Plateau have been grown successfully on an experimental basis under severe conditions in the Sawtooth Valley in Idaho. 3/

Listed below are countries which grow barley at a high altitude, with a brief description of the barleys found in these countries.

a. Tibet. Two types of barley are grown in Tibet; nas, a six-rowed, rough-awned barley used largely as an animal feed, and ne, a naked (hull-less), six-rowed, rough-awned barley used for human food. 12/ According to one authority, naked barley accounts for about 90 percent of the barley production in Tibet. 6/ There are many local types of naked barley in Tibet, but all are the large-headed blue, purple and white types common to the higher elevations of Central Asia. 3/ One author reports three principal types of naked barley in Tibet, yanaga or tukchung -- an early variety maturing two (sic) months after sowing; chibe-ne -- an "average" variety; and sarmo-ne -- the "best" variety, but later than the others. 12/

The cultivation of naked barley is largely limited to areas where barley is grown for food, even in Asia, where the greatest diversity of types is found. Naked barley, which resembles wheat or rye as the hulls do not adhere to the kernels of threshed grain, is preferred to common barley for human food in areas where only simple "milling" practices are employed (i.e., cracking or crushing the grain). 10/ In Tibet, the natives make a rough flour, tsampa, from parched naked barley. 12/

Although when brought down from its mountain home naked barley is less productive than common barley and is also less able to withstand unfavorable growing conditions, 6/ 2/ 1/ it is well adapted to high mountain regions for it is early maturing and resistant to subfreezing temperatures during its growing period. 3/ 2/ 13/

b. United States. Although one eminent barley breeder in the Department of Agriculture has flatly stated that there are no "commercial" quantities of naked barley adapted to high mountain areas available in the United States, 6/

it is possible that a diligent search might turn up the required quantities. Thousands of foreign varieties of barley have been introduced into the United States.*

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* The Department of Agriculture maintains a collection of some 7,000-8,000 varieties. 14/ This collection is supplemented by those maintained in State and private collections.

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Many of these varieties have been tested at experiment stations; a smaller, but still considerable, number of these varieties have been developed by State and Federal plant breeders and eventually released to farmers for commercial production.

If the desired types of barley are to be located in the United States they probably will be found either in the Rocky Mountains, or the Great Basin area, as only in these areas "have attempts to breed such barleys met with any success." 3/ Most of the experimentation and commercial production of naked barley in the United States has been in Montana and Idaho. A summary of the limited data available on this experience is presented below:

Nepal barley is a six-rowed naked type with hoods in place of awns. It was introduced from Nepal about 1840 and was the foundation for all hooded barleys grown in the United States. "Its appeal to farmers was immediate and lasting. Although the yield is unsatisfactory, except in a few areas, seedsmen have always found it profitable to carry Nepal or Nepal hybrids." 13/ There is no record of the acreage planted to Nepal in the United States.

Faust is a hooded, naked, six-rowed barley of the Nepal type. It is reported to have produced high yields, for a naked barley, in western Montana. This variety was grown on 6,000 acres in 1935, all in Montana. 13/

Himalaya is a blue, naked, rough-awned, six-rowed barley. It is reported to have the highest yield of any naked variety grown in the United States. It was grown on 5,000 acres in 1935, largely in Montana. 13/ Himalaya "is a common barley of central Asia and extends to the higher altitudes in northern India. It has been imported many times, tested at most of the experiment stations in the United States, and released at various places." 13/

Pamir is an early barley introduced from the Pamirs, near Kashgar, Eastern Turkestan. Among a [redacted] varieties tested by Dr. H. V. Harlan, USDA, [redacted] production of barley in high mountain valleys, Pamir was "obviously the best." It produced a good yield of seed having a high percentage of germination and "was not only as hardy as the others, but it was early." In his enthusiasm for Pamir, Dr. Harlan stated, "When the time comes to promote the growing of barley in high cold places I hope Pamir will still be available in our collection."3/

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Everest, a variety collected by the Mount Everest expedition at an altitude of 14,000 feet, 6/ proved to be satisfactory in the experiment mentioned above; 3/ several varieties from the Ethiopian Plateau proved to be "very hardy." 3/

c. India, Pakistan, Nepal, Afghanistan Kashmir, Bhutan, and Sikkim. From the foregoing discussion of the varieties of barley which have proven to be successful in high mountain areas in the United States, it is evident that the high mountain complex of Central Asia is the most fruitful source for seed of these adapted varieties. It is probable that the seed of almost any variety from this area, which was grown at an altitude of about 14,000 feet in its native locality, could be grown successfully at a similar elevation elsewhere.

d. Ethiopia. Strange as it may seem, the Ethiopian Plateau apparently is another good source of barley varieties adapted to high mountainous regions. As stated in preceding paragraphs, Ethiopian varieties have been grown successfully on the margins of Lake Titicaca in the Andes at an elevation of 13,000 feet, 3/ and in the Sawtooth Valley in Idaho under extremely rigorous climatic conditions. [redacted]

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The barley of the Ethiopian Plateau is mostly of an irregular type, peculiar to Ethiopia (with two minor exceptions). It is neither a two-rowed or six-rowed variety. Many of the lateral flowers are aborted resulting in an irregular head or spike. 3/ A six-rowed black barley also

is found on the Ethiopian Plateau. 3/

e. Bolivia and Peru. The barley grown on the Bolivian Plateau at an elevation of 13,000 feet is a six-rowed rough-awned variety. It is the same type of North African barley which was introduced into Latin America, Mexico and California by early Spanish missionaries. 3/ 4/

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